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UNITED STATES PATENT APPLICATION

FOR

METHOD AND APPARATUS FOR RECOVERING FROM AN OVERHEATED MICROPROCESSOR

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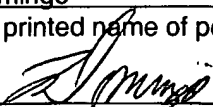SEVENTH FLOOR
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METHOD AND APPARATUS FOR RECOVERING FROM AN OVERHEATED MICROPROCESSOR

FIELD OF THE INVENTION

The present invention pertains to the field of computer systems. More

5 particularly, this invention pertains to the field of recovering from overheated

microprocessors.

BACKGROUND OF THE INVENTION

Today's microprocessors typically use cooling fans mounted to the processor

package to ensure that the processor continues to operate within acceptable temperature

10 limits. If the cooling fan should ever fail, or if other circumstances arise that cause the

internal temperature of the processor to exceed a maximum acceptable limit, then a

typical processor will assert a thermal trip signal that indicates to the rest of the computer

system that the processor has overheated. The processor will then enter a halt state and

system operation will cease.

15 A problem may arise as processors are manufactured with smaller and smaller

transistor dimensions. As transistor dimensions decrease, the leakage currents increase

dramatically. In the case discussed above where a processor has entered a halt state

following an assertion of the thermal trip signal, if the leakage currents of the processor

exceed the ability of the processor package to dissipate heat, then the processor's die

20 temperature will continue to increase. As the die temperature increases, the leakage

currents increase even more. This spiral continues until the temperature increases to the

point where the circuits on the die are damaged.

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BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be understood more fully from the detailed description given

below and from the accompanying drawings of embodiments of the invention which,

however, should not be taken to limit the invention to the specific embodiments

5   described, but are for explanation and understanding only.

Figure 1 is a block diagram of a system implemented in accordance with one

embodiment of the invention.

Figure 2 is a flow diagram of one embodiment of a method for recovering from

an overheated processor.

DETAILED DESCRIPTION

One embodiment of a system for recovering from an overheated processor includes a processor that asserts a thermal trip signal when the internal temperature of the processor exceeds a maximum acceptable limit. A power management device asserts a

5   power off signal to a voltage regulator module in response to the assertion of the thermal trip signal by the processor. The voltage regulator module removes power from the processor in response to the assertion of the power off signal by the power management device.

Figure 1 is a block diagram of a computer system 100. The system 100 includes

10   a processor 110. The processor 110 may include a cooling fan (not shown) coupled to the processor package. The processor 110 receives its power from a voltage regulator module 150. The delivery of power in this embodiment is designated by a processor voltage line 151. The processor 110 has an internal thermal sensor. If the cooling fan fails, the processor 110 may overheat. When the internal temperature of the processor

15   110 exceeds a maximum acceptable limit, the processor 110 asserts a thermal trip signal 111 that communicates to the remainder of the system that the processor is in an overheated condition. The processor 110 also enters a halt state where the processor ceases to execute instructions.

The thermal trip signal 111 is delivered to a system logic device 120. The system

20   logic device 120 includes a reset unit 140 and a power management unit 130. The power management unit 130 receives the thermal trip signal 111. In response to the assertion of the thermal trip signal 111, the power management unit 130 asserts a power off signal 131. The power off signal 131 is received by the voltage regulator module 150. In

response to the assertion of the power off signal 131, the voltage regulator module 150 ceases to deliver power to the processor 110. By removing power from the processor 110, the processor 110 will not continue to increase in temperature due to leakage currents as may otherwise occur if the power were to continue to be delivered to the

5   processor 110.

At some point after the assertion of the thermal trip signal 111, the power management unit 130 starts a timer 132 and sets a status bit 134. The timer 132 may be programmable. When the timer 132 expires, the reset unit 140 asserts a reset signal 141 to the processor 110. The power off signal 131 is deasserted and the voltage regulator

10   module 150 begins to again deliver power to the processor 110.

After restarting the processor 110, the power management unit 130 will take steps to keep the processor's heat generation to a minimum. In one embodiment, the power management unit 130 periodically asserts a stop clock signal 133. The stop clock signal 133, when asserted, causes the processor 110 to temporarily cease to execute instructions.

15   Therefore, a periodic assertion of the stop clock signal 133 effectively slows down the processor 110 so that less power is consumed and less heat is generated. This technique is commonly referred to as "clock throttling."

In another embodiment, the processor 110 is restarted to run at a lower frequency, and thus generate less heat. By running at a lower frequency, the voltage to the CPU can

20   also be reduced.

An additional embodiment includes running the processor 110 at a lower frequency and at a lower voltage, as well as throttling the clock to reduce the instruction rate.

By restarting the processor 110 in a manner that consumes less power, the processor 110 can continue to perform critical tasks. The processor 110 may also be able to deliver a failure message to a network administrator if the computer system 100 is incorporated into a network environment. The status bit 134 is used to indicate to the computer system basic input/output system (BIOS) software the reason for the system reset.

It is possible that even with the clock throttling the processor 110 may again overheat. In this case, the process described above is repeated. Some embodiments may track the number of times the processor is reset due to overheating. When a maximum number of resets has occurred, the power management unit 130 will cease to reset the processor and will keep the power off signal 131 asserted.

The response to successive overheat conditions may be increasingly drastic responses. For example, after the first overheat, the processor 110 may be restarted with clock throttling, but at full voltage and frequency. If a subsequent overheat occurs, then the processor may be restarted with clock throttling and voltage reduction and frequency reduction.

The timer 132 can be programmed with a value that will give the processor 110 time to cool off before the reset unit 140 resets the processor 110. Some embodiments may allow the BIOS to program the timer 132. The timer 132 may be reprogrammed to different values between each reset, if desired. Other embodiments are possible that use temperature measurements instead of a timer to determine when to reset the processor 110.

Although the example embodiment of system 100 describes the power management unit 131 as being integrated into a system logic device, other embodiments are possible where the power management unit 130 is either integrated into other system devices or is implemented as a discrete device.

5   Further, although the example embodiment of system 100 includes a voltage regulator module that delivers power to the processor 110, other embodiments are possible using a wide range of devices that are capable of delivering power to a processor. Also, although the system 100 indicates that a single voltage line is applied to the processor 110, other embodiments are possible where more than one voltage is applied to

10   the processor. For example, the processor core may receive one voltage and the processor input/output ring may receive a second voltage.

Figure 2 is a flow diagram of one embodiment of a method for recovering from an overheated processor. At block 210, a determination is made as to whether a processor overheat condition has been detected. If an overheat condition is detected, then at block

15   220 power is automatically removed from the processor. The term "automatically" as used herein is meant to indicate that no human interaction is necessary. The removal of power from the processor allows the processor to cool, thereby avoiding damaging the processor die. As described above in connection with Figure 1, other embodiments are possible where the processor is reset and is allowed to operate at a reduced power level in

20   an attempt to avoid further overheat conditions and to give the processor time to send messages to network administrators or to complete critical applications.

In the foregoing specification the invention has been described with reference to specific exemplary embodiments thereof. It will, however, be evident that various

modifications and changes may be made thereto without departing from the broader spirit

and scope of the invention as set forth in the appended claims. The specification and

drawings are, accordingly, to be regarded in an illustrative rather than in a restrictive

sense.

5   Reference in the specification to "an embodiment," "one embodiment," "some

embodiments," or "other embodiments" means that a particular feature, structure, or

characteristic described in connection with the embodiments is included in at least some

embodiments, but not necessarily all embodiments, of the invention. The various

appearances of "an embodiment," "one embodiment," or "some embodiments" are not

10 necessarily all referring to the same embodiments.